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PSC Overview Series . . .

Air Quality Issues for Electric Power Generation

Public Service Commission of Wisconsin

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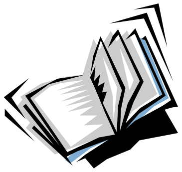
This Overview presents information about major air quality concerns related to electricity generation, particularly from fossil fuel combustion. Most state government review of air quality issues is conducted by the Bureau of Air Management in the Wisconsin Department of Natural Resources (DNR). The Public Service Commission (PSC) also reviews air quality issues associated with construction applications.

- Renewable Energy Resources
- Right-of-Way and Easements in Electric Facility Construction
- Underground Electric Transmission Lines

To obtain any of these Overviews, contact the Public Service Commission, by phone (608) 261-8524 or e-mail *pscrecs@psc.state.wi.us*, or check our home page at : http://www.psc.state.wi.us.



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PSC Overview Series

The Public Service Commission has prepared other Overviews for important electric issues. These are:

- Common Power Plant Siting Criteria
- Electric Energy Efficiency
- Electric Power Plants
- Electric Transmission Lines
- EMF—Electric and Magnetic Fields
- Environmental Impacts of Electric Transmission Lines
- How to Participate in Public Hearings
- Merchant Plants and Other Non-Utility Generation
- Nuclear Decommissioning and Radioactive Waste Disposal

Introduction

Much of Wisconsin's electricity supply is generated in power plants that burn coal, natural gas, or oil. Future new generation in the state may burn plant materials. For all of these fuels, the process of combustion emits nitrogen oxides (NO_x), carbon dioxides (CO_2), and particulates to the air. The amount of these emissions vary by the type of fuel. Nitrogen oxides and sulfur oxides (SO_2) form acid rain.

In some cases, these air pollutants have negative environmental or health effects. Control technologies can be installed to collect some troublesome emissions or to prevent them from being emitted. New air quality standards have been set recently for ozone and fine particulates.

Five major, interrelated air quality topics are discussed in this Overview for electricity generation using fossil fuels:

- Global warming,
- Acid rain,
- New national standards for ozone and fine particulates,
- Regional actions to meet new and existing national ozone standards, and
- Hazardous air pollutants, including mercury.

All of these topics are interrelated. For example, if coal-fired power plants are switched to natural gas, they decrease emissions of SO_2, NO_x, CO_2, and mercury, reducing global warming, acid rain, and the formation of ozone and fine particulates. If new gas-fired power plants are built to replace existing coal-fired power plants, statewide emissions of SO_2, NO_x, CO_2, and mercury will decrease.

Global Warming and CO_2

Global warming occurs when water vapor and CO_2 in the atmosphere trap or reflect heat back to the surface of the earth. If this did not occur, the earth would be about 60°F cooler than it is. As combustion of fossil fuels occurs, bound carbon is released into the atmosphere as CO_2.

Global warming may be slowed or reduced if emissions of CO_2 decrease. In the United Nations Framework Convention on Climate Change (the Rio Accord) industrialized countries adopted a nonbinding goal of reducing emissions to 1990 levels by 2000. The follow-up Kyoto Accord will require the U.S. to reduce emissions to 93 percent of the 1990 level of emissions by 2008 to 2012 if the Accord is ratified by the U.S. Senate and signed by the President.

There are three major ways to reduce CO_2 emissions from the production and use of electricity: generating electricity with more efficient technology; using electricity more efficiently; and switching to fuels with a lower carbon content (e.g., from coal to natural gas). Combined-cycle gas-fired units are more efficient than simple combustion units because the fuel energy makes both electricity and steam. Over half of the energy in the fuel is used productively in combined-cycle gas-fired units, compared to 34 percent in most existing gas-fired power plants. Advanced turbine systems, advanced fuel cells, and pressurized fluidized bed combustion are all generation technologies that will offer increased efficiency and reduced emissions when they become available.

The DNR has published several studies related to greenhouse gas emissions since 1993. Two studies estimated emissions in 1990 and projected future emissions through 2010. Estimated 1990 emissions were 141 million tons. Projected 2010 emissions are 181 million tons. A third study, in cooperation with other agencies and organizations, estimated the costs to reduce emissions in the electric industry and transportation

Quality Agreement. In 1987, the agreement was amended to include a collaborative process involving the states, provinces, tribes, and first nations in the Great Lakes watershed to work toward virtual elimination of persistent toxic substances resulting from human activity. The emphasis was on substances that bioaccumulate. Mercury was one of the substances to be addressed first, along with cadmium, lead, dioxins, furans, PCBs, and several pesticides. One of the challenges for the U.S. under this agreement is to seek a 50 percent decrease in the release of mercury from human activity by 2006. This is an interim target that could change. Other sources of mercury such as burning municipal and medical wastes will have to reduce mercury emissions under the new EPA regulations.

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re-emitted after deposition. It is very difficult to control in the environment. It is not possible to say that what fraction of mercury in the fish of a specific river or lake comes from a particular power plant, state, or country. The EPA believes that mercury emitted from coal-fired power plants is the hazardous pollutant of greatest concern from fossil-fueled electric power plants.

When mercury is deposited in water, it is converted to methyl mercury. Methyl mercury bioaccumulates and predatory fish have the highest concentrations in a lake or river. High concentrations of mercury in fish are a frequent cause for DNR fish advisories (warnings to limit consumption). The greatest health risk to humans is neurotoxicity to a fetus if the mother eats too much fish containing methyl mercury.

About one-third of the U.S. mercury emissions are deposited within the U.S. and the rest enters global circulation. About 35 tons per year are deposited in the U.S. from global circulation. Total annual global emissions of mercury are 5,000 to 5,500 tons. About 1,000 tons come from natural sources. About 2,000 tons are re-emitted from previous human caused emissions. About 2,000 tons are new emissions from: coal-fired power plants; metal ore roasters, refiners, and processors; and incinerators of municipal, medical, and hazardous wastes. The 1994, U.S. power plant emissions of mercury were about 51 tons; about one-third of the U.S. total emissions of 158 tons. In 1996, Wisconsin power plant emissions were 1.13 tons.

There are no commercial control technologies for power plants that would specifically control mercury. If coal-fired power plants were modified to burn natural gas to reduce CO_2 emissions, emissions of mercury would be almost eliminated as well. (If oil is burned as a backup fuel, some mercury would be emitted.)

In 1978, the U.S. and Canada created a Great Lakes Water

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sectors. That study found that electric energy conservation could reduce CO_2 emissions by 8.4 million tons with a net savings of $444 million. Program costs to encourage use of more efficient equipment were not included in the savings estimate. The study assumed that appliances would be replaced with more efficient models at the end of life for the older appliances. If measures costing up to $100 per ton of CO_2 were used, emissions could be reduced by 32 million tons at a cost of $4 per ton and a total cost of $138 million.

If all coal-fired power plants in Wisconsin were converted to natural gas, emissions of CO_2 would be reduced by 21 million tons. This conversion would also significantly reduce emissions of NO_x, mercury, and other air toxics from power plants. However, this would more than double the use of natural gas in the state of Wisconsin and construction of large new gas pipelines would be needed to significantly increase the amount of available gas in Wisconsin.

Another approach toward a net reduction in CO_2 in the atmosphere is to reforest land where trees have been removed and to support such projects in other countries. Tree growth removes CO_2 from the atmosphere while reducing soil erosion. At least one Wisconsin utility has invested in projects that support tree planting and preservation of forested areas.

The Wisconsin Climate Change Committee (representing Wisconsin state agencies, utilities, businesses, and environmental groups) is studying possible actions that the state can take. So far, suggested actions include: energy efficiency measures in state-owned buildings, purchases of energy efficient equipment, use of efficient and/or alternate fuel vehicles by state agencies, increased use of public transit by state employees, and encouraging the private sector to adopt energy efficient measures.

Acid Rain

Acid rain can damage stone buildings and statues, vegetation, soil nutrient levels, surface and groundwater quality, and aquatic life. The Acid Rain Law, part of the Clean Air Act Amendments of 1990, requires two major phases of emissions reduction for SO_2 and NO_x and puts a permanent cap on SO_2 emissions from electric utilities. The SO_2 reduction strategy includes a market-based SO_2 allowance trading approach that allows utilities to use the most cost-effective techniques to reduce emissions. Utilities may reduce emissions by using more renewable energy, encouraging more energy conservation, switching to lower sulfur fuel, adding pollution control equipment, or developing other strategies.

SO_2 emissions

The first phase of the Acid Rain Law required reductions on 110 coal-fired power plants across the nation, beginning on January 1, 1995. Phase I reduced SO_2 emission rates from these plants by about 3.5 million tons (about 20 percent less than 1990). Phase II will tighten emissions significantly beginning on January 1, 2000. Phase II will cover all power plants in the country over 25 MW in size and is expected to reduce SO_2 emissions to 9.48 million tons by 2009 (40 percent less than 1980) and to 8.95 million tons after January 1, 2010, (50 percent of 1980)

In 1996, this law affected 424 power plant units in the nation. The Act required 263 units to participate and utilities that owned these units elected to include 161 additional units. The required units were large with high emission rates. They had emitted over 60 percent of all utility SO_2 in 1987.

Power plants are issued allowances, each allowing emission of

Sixty-seven hazardous air pollutants were identified from utility power plants. Four were found to be persistent or to "bioaccumulate" (that is, increase progressively in the tissues of animals when moving up the food chain) and be toxic in food or water, or to be in radioactive form. These four pollutants: radionuclides, arsenic, dioxins, and mercury were analyzed for risks posed by inhalation or ingestion with food and water.

Cancer risks

The EPA study identified inhalation exposures and risks in general for areas within about 30 miles of a power plant. An accepted risk assessment model called the Human Exposure Model was used. Where data were missing, assumptions that overestimated risks were used.

Generally, cancer risks from fossil fuel power plants was low. Risks from natural gas-fired power plants were found to be less than one in a million. Among coal-fired plants, they were also less than one in a million for 424 of the 426 plants in the U.S. The cancer risk for all 426 coal-fired power plants from exposure within 50 kilometers (about 31 miles) was no greater than one case every 5 years. The greatest risk from coal plants was from arsenic and chromium emissions. For the 125 oil-fired power plants studied, the risk of cancer was less that one in a million. For 11 oil-fired plants, the risk was above one in a million.

If exposure at greater distances were considered, the risk from coal plants would increase to 1.3 cancers per year. The total risk from coal-and oil-fired power plants for increased occurrence of cancer was 1.8 cases per year.

Mercury

Mercury is environmentally persistent and toxic and, in the elemental form, can travel for thousands of miles. It may be reductions, Wisconsin power plant owners would need to install NO_x emissions controls by 2002 to 2007 that limit the emission rate to 0.15 lbs./MMBtu. These controls cost several hundred million dollars. With operating costs, the estimated annualized total could be $50 to $120 million. This estimated range of costs is based on a control cost range of $1,000 to $2,500 per ton, which brackets the EPA estimate of $1,700 per ton. This considerable expense could lead to changes in Wisconsin's generation mix in a short time, as costlier plants are used less, more efficient plants are used more, and new efficient plants are built. In addition, the EPA's aggressive proposed implementation schedule could negatively affect the reliability of the state's electricity production system.

Other large stationary sources in the state are projected to reduce summertime emissions to equivalent emission rates ranging from 40 to 70 percent of the predicted 2007 emissions (tons).

Hazardous Air Pollutants (Air Toxics)

Hazards to public health from electricity generation

A section of the Clean Air Act Amendments, s. 112(n)(1)(A), directed the EPA to study the hazards to public health anticipated as a result of emissions from fossil fueled electric steam generating units of more than 25 MW. This study was sent to Congress in January 1998.

The study used the most recent emissions data to represent 1994 emissions and assumed that the requirements of the Act were met to estimate emissions for 2010. It identified a total of 684 utility plants across the nation. Of these, 426 plants burned coal at least some of the time, 137 plants burned oil, and 267 plants burned natural gas. Many of the plants burned more than one type of fuel.

one ton of SO_2 during or after the year that the allowances are issued. Possession of sufficient allowances does not permit emissions that cause a violation of ambient air quality standards. The U.S. Environmental Protection Agency (EPA) deducts allowances to match emissions, as measured in each stack. Allowances may be traded. Actual SO_2 emissions in 1995 and 1996 were 61 and 65 percent of allowed emissions.

Environmental data reflect the decreasing emissions. Large areas of the eastern U.S. experienced a decrease in the sulfur concentration in rain in 1995 and in the dry deposition of sulfur. Preliminary data being analyzed from 1996 show similar results.

In Wisconsin, the Acid Rain law affects 68 coal-fired units at 21 sites, and has required 13 units to participate since the beginning of Phase I (1995 to 1999) of the program. Sixteen units are substitution units. The remaining 39 units will be affected by Phase II (2000 and beyond) of the program. All the major Wisconsin utilities are selling allowances during Phase I. Actual Wisconsin emissions in 1996 were 38 percent of the allowances held by Wisconsin Phase I units. Wisconsin utilities state that they have sufficient allowances through 2007.

NO_x emissions

The Clean Air Act Amendments of 1990 also set new emission rates for NO_x for power plants. In Phase I, beginning in 1996, new emission rates were set for the nation's dry-bottom, wall-fired boilers and those tangentially-fired boilers identified in the Phase I SO_2 regulations in 1995. In Phase II, 709 boilers across the country will be affected. They are of a variety of types, as shown in Table 1.

Table 1 Boiler types subject to NO_x compliance

In Phase II, the emission rates for wall-fired and tangentially-fired boilers will be reduced slightly and emission rates are established for four other types of boilers. The goal of these changes is to reduce power plant NO_x emissions to 2 million tons below the 1980 levels. NO_x emissions are

Phase I			
Boiler Type	**Emission Limit (lbs./MMBtu)**	**Number Affected in the**	**Substitution Units**
Tangentially-fired	0.45	82	42
Dry bottom wall-fired	0.50	62	53

Phase II		
Boiler Type	**Emission Limit (lbs./MMBtu)**	**Number Affected in the**
Tangentially-fired	0.40	308
Dry bottom wall-fired	0.46	299
Cell burners	0.68	36
Cyclones >155 MW	0.86	55
Wet bottoms > 65 MW	0.84	26
Vertically-fired	0.80	28

expected to be reduced by over 400,000 tons per year (33 percent below 1990 for these 239 units) beginning in 1996 and by 2,060,000 tons per year (26 percent below 1990 for all units) beginning in 2000. The lower emission rates can be achieved by using special "low NO_x burners" that limit the amount of oxygen available for combustion in the first part of the combustion zone.

New National Air Pollution Standards for Ozone and Fine Particulate Matter

Ozone—timeline for planning and control requirements of new EPA standards

In 2000, the EPA will designate areas that had ambient ozone levels above the revised (eight hour) standard between 1997 and 1999. States in these areas will submit new or revised plans to the EPA by 2003 to reach attainment of the standards between 2007 and 2010. States with one-hour violations will also continue to plan for attainment of that standard until attainment with the one-hour standard is accomplished.

The EPA will also designate transitional areas that meet the old standard but violate the new standard. These areas will need little or no additional emission reductions to reach attainment beyond the regional power plant NO_x emission reductions to decrease upwind production and transport of ozone.

In 2004, states should begin seeing significant ozone reductions resulting from reduced transport of ozone formed upwind. This target year may change if the EPA revises the reduction schedule in response to comments on the proposed rule. The final rule calling for NO_x reductions is expected to be published in the fall 1998.

In 2007, states will assess the effectiveness of the regional reductions. Additional local NO_x or volatile organic carbon reductions may be needed to meet the standard. Overall, states may have until 2012 to meet the new ozone standard.

Potential effects of the new EPA standards on Wisconsin electricity generation

Under the EPA's proposal for Wisconsin, a 33 percent reduction from the predicted 2007 emissions would be required (including a 62 percent reduction by utilities). To achieve these

- Ozone benefits are greatest where the emission reductions are made; the benefits increase with distance.

- NO_x reductions from elevated sources (tall stacks) and at ground level (houses or autos, for example) are both effective in reducing regional ozone concentrations.

- VOC controls are also effective in reducing local ozone levels. (Significant reductions have occurred in Wisconsin ozone nonattainment areas already, based primarily on VOC reductions.)

In November 1997, the EPA proposed to call on 22 states in the eastern U.S. to submit new NO_x and VOC emissions limits for sources that contribute to nonattainment of the ozone standard in other states. The EPA would use the projected NO_x and VOC data for 2007 air quality modeling to: (1) identify areas that might remain nonattainment for both one-hour and eight-hour standards in 2007 and (2) identify the upwind sources and source areas that contribute to nonattainment.

Though not requiring specific NO_x controls on specific facilities, the EPA has also proposed future summertime (May 1 to September 30) NO_x budgets on a state-by-state basis. To set the budgets, the EPA has projected an average NO_x emission rate of 0.15 lbs./MMBtu during the 5-month ozone season for electric power plants in the 22 OTAG states. The EPA has proposed that states reduce emissions to meet their budgets by 2002 or 2004. The states may use a cap and trading system, similar to that used to reduce acid rain, to reduce the cost of the emission reductions.

The EPA requirements are expected to be finalized in fall 1998. Until then, it is not clear what level of reductions will be required, when all reduction technology must be installed, or whether all or part of Wisconsin would be included in the area in which reductions must occur.

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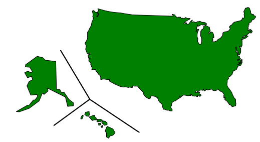
The EPA revised two ambient air quality standards in 1997: ozone and particulates. These new standards are based on ambient air quality impact on public health. Secondary limits have been set to address social welfare (economic) impacts. This is the first time the ozone standard has been changed in 20 years. It is the first time the particulate standard has been changed in 10 years. Part of the standard review process is a thorough review by the Clean Air Scientific Advisory Committee, a national group of independent scientific and technical experts familiar with air quality studies.



Ozone formation, standards, and health impacts

Ozone forms when NO_x and volatile organic compounds (VOC) react in the presence of sunlight. NO_x is emitted during combustion, with more emitted from high temperature combustion. VOCs (or reaction hydrocarbons) come from evaporation of petroleum fuels and solvents and incomplete combustion processes.

The new ozone standard replaces a one-hour standard with an eight-hour standard (measurements are averaged over one hour or eight hours). The existing one-hour standard is 0.12 ppm (parts per million). If one one-hour ozone average is over 0.12 ppm, the area near that monitor is not in attainment. The new eight-hour standard is 0.08 ppm. A three-year average of the fourth highest daily maximum will determine compliance. An eight-hour standard is more closely related to health effects than a one-hour standard.

Increased ozone concentrations are associated with chronic lung problems such as bronchitis and asthma as well as decreased lung function in children, the elderly, and healthy adults working or exercising outdoors. Long-term exposure to ozone can cause irreversible lung damage. In the northeast U. S. and southern Ontario and Quebec, high ozone concentrations are associated with 10 to 20 percent of all summer respiratory-related hospital admissions, including those for asthma. The fraction of the population with asthma is increasing. Between 1982 and 1994, the rate of asthma in children under 18 increased 72 percent; in people aged 18 to 44, the increase was 78 percent; and in people aged 45 to 66, the increase was 40 percent.

Ozone also decreases agriculture and commercial forest yields, decreases the growth and survivability of tree seedlings, and increases the susceptibility of plants and trees to disease, pests, and other stresses like drought.

Fine particulates—ambient air quality standards and health impacts

Fine particulates ($PM_{2.5}$) include sulfates and nitrates that form downwind from the oxidation of SO_2 and NO_x emitted from power plants, other large sources, and automobiles. Combustion in residential fireplaces and wood stoves also produce $PM_{2.5}$. Power plants that burn coal, natural gas, oil, or biomass emit the precursors that form $PM_{2.5}$.

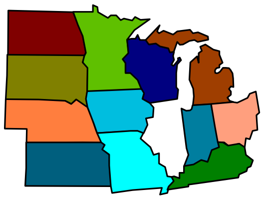
Monitors to measure levels of $PM_{2.5}$ will be installed between 1998 and 2000. The initial network will consist of about 1,500 monitors. The EPA will pay for the monitors. The EPA will designate areas as attainment or nonattainment between 2002 and 2005. States will then have until 2005 to 2008 to submit plans to meet the $PM_{2.5}$ standard. States may have up to 12 years to implement and achieve approved standards.

Fine particulates contribute to the haze that has decreased the visual range from 90 miles to 14 to 24 miles in the eastern U.S. and from 140 miles to 30 to 90 miles in the western U.S.

Fine particulates also penetrate and remain in the deepest passages in the lungs. Increased concentrations of $PM_{2.5}$ are linked to premature deaths, increased admissions to emergency rooms, chronic bronchitis, and aggravated asthma. The new standards are expected to prevent 15,000 premature deaths and hundreds of thousands of cases of aggravated asthma in adults and children. Asthma is the leading chronic illness in children. There is no standard that fully protects all people. More health effects research will be done in the five years between 1997 and 2002, and that research can be evaluated in 2002, before states must submit compliance plans.

Regional Actions to Meet New and Existing National Ozone Standards

For over two years, the Ozone Transport Assessment Group (OTAG), including representatives from the EPA, state environmental agencies, utilities, and health and environmental groups, discussed strategies to reduce the transport of ozone and its precursors as far west as western North Dakota and Texas. In July 1997, OTAG reached several conclusions:



- Regional NO_x reductions would be effective in reducing ozone concentrations; the more NO_x reduced, the greater the ozone reduction.
- Air quality data indicate that ozone is pervasive, is transported, and once it is aloft, ozone can be carried over and transported from one day to the next.
- The range of transport in the U.S. is greatest in the Northeast, the next greatest in the North Central area and least in the Southeast; but all areas show cross-state impacts.